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Knowledge Networks of the Information Technology Management Domain: A Social Network Analysis Approach

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Abstract:

Using the social network analysis technique, we decomposed the knowledge networks of the information technology management (ITM) domain. We included a total of 893 papers published during the 1995-2014 period in the network analysis. From this domain, the network and ego level properties—such as, degree centralities, density, components, structural holes, and degree distribution—suggest that, unlike the other information systems communities, the ITM is a community with a unique character and distinct collaboration patterns. The results show that the ITM knowledge networks are fragmented and exhibit a power law distribution in which incoming nodes and links prefer to attach to the nodes that are already well connected. We discuss several implications that arise from the network configuration that could aid the future development of the ITM domain.

Keywords: Information Technology Management Domain, Knowledge Networks, Co-authorship Networks, Social Network Analysis.

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1 Introduction

Scientific knowledge networks, such as citations (Price, 1965), co-authorships (Oh, Choi, & Kim, 2006), and keywords networks (Choi, Yi, & Lee, 2011), emerge when authors, institutions, outlets, and countries collaborate to co-create new knowledge. Embedded in these knowledge networks is a power game where authors, outlets, nations, and topics joust for authority and influence. To study the hidden nature of these networks, scholars have sought to use innovative approaches including the social network analysis (SNA) technique (Wasserman & Faust, 1994). SNA is a structured way of analyzing relationships in groups by providing a rich and systematic means of assessing informal networks by mapping and analyzing relationships among entities, including people, teams, departments, or even entire organizations (Cross, Parker, Prusak, & Borgatti, 2001). Researchers have used the SNA technique to analyze and map knowledge networks formed by information system (IS) and its allied research communities, including electronic government communities (Khan & Park, 2013), information technology (IT) outsourcing communities (Swar & Khan, 2013), the social media-based systems research domain (Khan, 2013), information and communications technology research communities that focus on developing countries (Swar & Khan, 2014), the International Conference on Information Systems (ICIS) community (Xu & Chau, 2006), and the European Conference on Information Systems (ECIS) (Vidgen, Henneberg, & Naude, 2007) and Researchers Seminar in Scandinavia (IRIS) communities (Trier & Molka-Danielsen, 2013).

Nevertheless, the grounding and knowledge that we possess regarding hidden knowledge networks of the information technology management (ITM) domain, as one of the core IS/IT related communities, remains poorly understood mainly because no study has attempted to study the ITM knowledge networks from the SNA perspective. Like in any other field, academics and institutions operating in a complex social world forming different knowledge networks, such as citations (Price, 1965) and co-authorship networks (Newman, 2004), form the ITM research domain's backbone. While these networks are crucial to the ITM domain's identity, we know little about the existing structure and health of these hidden networks. The hidden network structures can provide an understanding of the “fields of power” that dominate and influence the network (Bourdieu, 1993). The hidden structure of the network itself is important because it can impact the content, output, or performance of those involved in its boundaries (Vidgen et al., 2007). For example, how does the ITM community collaborate? Is the knowledge network fragmented or well formed? How does the ITM community structurally compare to other IS/IT communities? How are certain authors and intuitions positioned in the network? What research themes are trending and which are fading? Understanding these questions help one to identify whether problems and opportunities exist in the way certain authors, institutions, or countries collaborate.

As a consequence, this gap invites research into the hidden identity of the ITM domain from a SNA perspective. By using the SNA technique and a large number of publications (from journals, conferences, and editorials, etc.), we study the hidden structures associated with ITM networks and, thus, provide a highly comprehensive view of the knowledge networks of the ITM domain. The SNA technique allows one to not only measure, monitor, and evaluate the knowledge flows and relationships in a network (Serrat, 2009) but also identify the key players in a ITM knowledge network and structural holes at the network level that can be strategically filled to accelerate knowledge flows (Khan & Park, 2013). Thus, we do not only focus on revealing the hidden structures of these knowledge networks but also on identifying the previously unknown critical knowledge gaps in the domain. The study will also help provide a basis for comparing the ITM network structure with other relevant IS communities.

To understand the hidden structures, we constructed, visualized, and investigated the ITM knowledge networks by analyzing publications that 40 outlets published and 1,879 authors from 914 institutions and 64 countries authored. For the purpose of this paper, we refer to knowledge network as being the scholarly networks that have been formed as a result of the collaborative works of researchers, institutions, countries, and journals that are dynamically engaged in helping shape, generate, distribute, and preserve the ITM domain's intellectual knowledge. We refer to these networks as knowledge networks in the sense that players form collaboration ties to create new knowledge in the form of publications. We investigated the knowledge networks at four levels: author, institution, country, and outlet. The results from this investigation define the ITM domain from a network perspective. In particular, we address the following research question (RQ).

RQ: What is the network structure of ITM knowledge infrastructure?

The question looks at both the network-level properties (such as components, diameter, density, the clustering co-efficient, and average degree) and the node-level properties (degree, betweenness, eigenvector, centralities, structural holes, and hubs) to study influential nodes (i.e., authors, institution, journals, and countries) in the ITM domain.

This paper proceeds as follows. In Section 2, we overview previous attempts to analyze IS and present ITM knowledge infrastructure. In Section 3, we examine the methodology we adopted for this study in depth. In Section 4, we document our results. In Section 6, we discuss and elaborate on our main findings. Finally, in Section 6, we conclude the paper.

2 An Overview of the Previous Research

Cattell (1906) performed the first attempt at understanding the field of knowledge infrastructure by ranking 1000 American Scientists. Subsequently, Garfield (1955) developed a science citation index. Despite the importance of these early works, Price (1965) provided the first really detailed assessment for studying scientific communities from a network-focused point of view. Since Price's pioneering network-based study, researchers have become increasingly interested in how knowledge is generated in research communities and the role that collaboration plays in furthering scientific development. As a consequence, numerous studies have showed an increase in the number of co-authored research papers (Krystallis, Ormond, & Christensen, 2011; Laband & Tollison, 2000; Moody, 2004). Currently, the literature surrounding the understanding of knowledge infrastructure in general is vast, with much work being done using a range of methodological approaches including systematic literature reviews, SNA, bibliographic analyses, scientometrics studies, and topic analyses. Among the methods used, the SNA is a technique that researchers have applied to understand hidden knowledge networks. In Section 2.1, we discuss the SNA technique in detail. In Section 2.2, we discuss the previous studies conducted using this method. In Section 2.3, we document an analysis of ITM knowledge infrastructure studies.

2.1 The SNA Technique and Knowledge Infrastructure Studies

One uses the SNA technique to describe a community and the individuals, groups, organizations, that form relationships in it (Tichy, 1981). SNA has its roots in graph theory (Biggs, Lloyd, & Wilson, 1986) and deals with mapping and visualizing relationships (such as, friendships, trade relationships, and co-authorships) among nodes (which can be individuals or institutions) (Wasserman & Faust, 1994). The SNA technique provides several benefits to researchers. For example, it helps them measure, monitor, and evaluate the knowledge flows and relationships in a network (Serrat, 2009). The SNA technique also qualifies as a "good literature review" method that can not only summarize pervious research but also identity critical knowledge gaps in a domain and propose new research venues (Rowe, 2014). One such area is the analysis of informal networks of academics collaborating on research papers. Because this type of network is characterized by the absence of any formal hierarchy, SNA can reveal patterns and regularities in a way in which academics can work together to generate knowledge (Krystallis, et al., 2011). Furthermore, it could disclose the structure that shapes the creation of knowledge in a given research field (Vidgen et al., 2007). One can also use it as a tool for conducting citation analyses (Carter, Leuschner, & Rogers 2007; Zinkhan, Roth, & Saxton, 1992) and for analyzing the network settings of research communities (Krystallis et al., 2011; Vidgen et al., 2007). The technique is also helpful in identifying key players in a knowledge network (such as key institutions, countries, and regions), structural holes at the network level that can be strategically filled to accelerate knowledge flows, and identifying sharing at institutional, national, and regional levels (Khan & Park, 2013). Next, we discuss some important knowledge infrastructure related to studies conducted in the IS field and ITM domain.

2.2 Information Systems Knowledge Infrastructure Studies

In the IS field, knowledge infrastructure-related studies have a long history in which scholars have attempted to better understand the IS field's nature, its publication outlets, its accomplishments, and the ways in which researchers collaborate and share knowledge. As part of these efforts, researchers have analyzed research in the IS field by employing several methodological approaches on a variety of topics (see Table 1, which clearly states the various approaches and relevant research areas).

Table 1. Past Research on Literature Analysis

Methodological approach	Research area/subareas	Author(s)
SNA	Information systems (IS), e-government, ICT, information management, organizational systems, social capital development in IS	Hassan (2009), Khan & Park (2013), Levina & Bobrik (2013), Cucchi & Fuhrer (2007), DeSantis (2003), Durst, Viol, & Wickramasinghe (2013), Swar & Khan (2013), Oh, Choi, & Kim (2006), Polites & Watson (2009), Vidgen et al. (2007), Worrell, Wasko, & Johnston (2013), Xu & Chau (2006), Zach (2000), Trier & Molka-Danielsen (2013)
Conventional literature review	IS, genre diversity in IS, IT outsourcing, business IT alignment strategies, IT business process management, IT future research streams, ITM research directions, online networks, social networks	Boell & Cecez-Kecmanovic (2014), Rowe (2014), Lacity, Khan, Yan, & Willcocks (2010), Xiao, Califf, Sarker, Sarker (2013), Aversano, Grasso, & Tortorella (2012), Ben-Menachem (2001), Berger, Klier, Klier, & Probst (2014), Iden & Eikebrokk (2013), Jeyaraj, Rottman, & Lacity (2006), Lacity et al. (2010), Litwin, Avgar, & Pronovost (2012), Menz (2011), Oinas-Kukkonen, Lyytinen, & Yoo (2010), Santos Rocha & Fantinato (2013), Simon, Fischbach, & Schoder (2013), Yang & Tate (2012)
Bibliographic/ Scientometrics	Authorship patterns in IS, IT data management, information science research patterns, research productivity in IS, comparative analysis of IS research journals, evolutionary analysis of IS emerging research trends in IS, intellectual structure of IS	Cunningham & Dillon (1997), Ding, Chowdhury, & Foo (2000), Hsu & Chiang (2015), Long, Crawford, White, & Davis (2009), Murad & Tomov (2012), Mutschke & Haase (2001), Newman (2004), Polites & Watson (2009), Pratt, Hauser, & Sugimoto (2012), Schlögl, Gorraiz, Gumpenberger, Jack, & Kraker (2014), Zhai, Li, Yan, & Fan (2014), Guo, Weingart, Borner (2011)
Topic analysis	Emerging trends in IS research, keyword analysis in MIS research, keyword analysis in management and IT	Chen (2006), Choi, Yi, Lee (2011), Kho, Cho, & Cho (2013), Whitley & Galliers (2007)

Important IS-related bibliometric studies (without the SNA component) include Mutschke & Haase (2001), who used socio-cognitive analysis to examine the relationship exists between actors' positions in scientific networks and the innovativeness of the themes they examine, Cunningham & Dillon (1997), who examined the patterns of authorship in five information systems journals, and Whitley & Galliers (2007), who identified the most frequently cited texts in IS literature (Whitley & Galliers, 2007). Other studies identified in the literature include Polites and Watson (2009), who examined the relationship among IS journals, and Guo et al. (2011), who used a scientometric approach to identify emerging research areas.

In IS and its allied fields, researchers have begun to use SNA to understand knowledge networks. For example, Cucchi and Fuhrer (2007) investigated the network structures embedded in email data and found relationships between personal traits, aspects of organizational power, and email network centrality. Khan and Park (2013) employed the SNA technique to study the hidden institutional, country, and regional network structures and the characteristics (such as degree centralities, components, diameter, and density) of the e-government knowledge network. Likewise, using the triple helix indicators and SNA techniques, Swar and Khan (2013) studied the knowledge networks associated with the IT outsourcing domain and revealed, among other things, the lack of research collaboration between developed and developing countries, which hindered the flow of IT outsourcing related knowledge among the countries. Swar and Khan (2014) applied a similar methodology to investigate and visualize the ICT knowledge infrastructure in South Asia by examining several network parameters including the degree centralities, density, and clusters of the domain. Researchers have also used the SNA technique to detail new research avenues for accounting information researchers (Worrell, Wasko, & Johnston, 2013). Zhai et al.

(2014) studied the evolution and trend of collaboration networks in the IS field. Similarly, Choi et al. (2011) analyzed keyword networks and their implications for predicting knowledge evolution.

Several other studies that use the SNA technique have focused on IS conference communities. For example, Vidgen et al. (2007) used the European Conference on Information Systems (ECIS) and measured this community's network properties using a range of centrality measures for individual authors including degree, betweenness, closeness, eigenvector, flow betweenness, and structural holes. Meanwhile, Trier and Molka-Danielsen (2013) examined the IRIS community network and how individual conceptions shape it using a similar range of centrality measures to that of Vidgen et al. (2007), Swar and Khan (2013), and Cucchi and Fuhrer (2007). Similarly, Xu and Chau (2006) measured the co-authorship structure of contributions to the International Conference on Information Systems (ICIS) to further illustrate an earlier study that examined the idea of social identity (DeSantis, 2003). Researchers have also applied SNA to certain IS journals. For example, Oh et al. (2006) used SNA to explore the ontological structure of knowledge sharing activities by researchers publishing in four core IS journals (*Information Systems Research, Journal of Management Information Systems, Management Science,* and *MIS Quarterly*). These studies have undoubtedly contributed to our understanding of the IS field's social identity and showcase the usefulness of the SNA technique.

2.3 ITM knowledge Infrastructure Studies

The ITM research we examined focuses purely on the governance and management of information technology (IT) (computer hardware, software, data, networks, people, and processes) to create business value. It involves the managerial efforts associated with planning, organizing, controlling, and directing the introduction and use of IT in an organization (Boynton & Zmud, 1987). The four key areas of the ITM domain are IT planning, IT organizing, IT leading, and IT controlling (Cragg, Mills, & Suraweera, 2010). Embedded in these areas is the key issue of whether or not IT executives have sought to combine strategic IT initiatives with an organization's overall mission, goals, and plans (Reich & Benbasat, 2000). Given its significance to business and the need to better understand the issues associated with the strategic alignment of corporate practices, an extensive array of literature has emerged (Huang, 2012) on, for example, the business roles of IT managers (Fonstad & Subramani, 2009), the cost-efficient use of IT (Earl & Fenny, 1994), the business value of IT (Bloch & Hoyos-Gomez, 2009), the agility of systems and IT personnel (Fink & Neumann, 2007), IT use and organizational agility (Tallon, 2003), and communication between IT and business counterparts (Johnson & Lederer, 2007). The existing ITM research mostly focus on the ways in which organizations have or have not sought to incorporate information technology (IT) initiatives (Jeffery & Leliveld, 2004; Lucas, 1999; Luftman, 2000, 2003). In this research area, researchers have documented much on IT's importance as a driver of business activity and value for organizations (Wilkin, 2012).

Unlike the other IS subdomains, after analyzing the literature, we found that most studies in the ITM domain are based on conventional literature reviews (CLR). We found several important ITM studies from a knowledge infrastructure point of view. For instance, Aversano, Grasso, and Tortorella (2012) evaluated literature related to different alignment approaches so as to better measure, model, and assess the alignment levels that exist among the technological aspects of a business. Meanwhile, Iden, and Eikebrokk (2013) systematically reviewed existing research related to the implementation of IT service management (ITSM) and Information Technology Infrastructure Library (ITIL) to provide IT managers with useful information on ITSM and ITIL. In other key literature reviews, Jeyaraj et al. (2006) analyzed 48 empirical studies on individuals and 51 studies on organizational IT adoption published between 1992 and 2003, and Lacity et al. (2010) adapted the previous Jeyaraj et al., (2006) study to develop two models of outsourcing, with one addressing ITO decisions the other ITO outcomes.

Nevertheless, from an SNA perspective, the ITM research remains unexplored and poorly understood. To understand the ways in which knowledge is created in the ITM domain, we need to examine and understand the hidden structures of the ITM research network. Thus, by incorporating the multi-level network analysis concept (i.e., authors, institutions, outlets, and countries) that Khan and Park (2013) use and the core centrality measures that several IS SNA studies (such as Vidgen et al., 2007; Cucchi & Fuhrer, 2013; Swar & Khan, 2013) identify, we examine the ITM domain's network-level (components, diameter, density, the clustering co-efficient, and average degree) and node-level properties (degree, betweenness, eigenvector, centralities, structural holes and hubs) to ascertain how its author-, institution-, journal-, and country-level networks are structured.

3 Method

3.1 Data

A high-quality and complete literature-identification strategy is not confined to one research methodology, one set of journals, or one geographic region (Webster & Watson, 2002). Thus, to obtain a complete picture of the ITM domain, on 9 September 2014, we performed a search experiment in the Web of Science (WoS) database to retrieve all ITM-related studies regardless of the methodology they employed, the publication outlet, or the publication region. To retrieve the ITM-related studies, we developed a comprehensive keyword list by 1) searching ITM-related keywords using Google search, 2) consulting the ITM curriculums taught in different universities, and 3) leveraging our own university teaching and research experience in the ITM domain. We entered the following research query into the WoS search engine to search for the publications (from 1986 to 2014 and across all databases) with the following topics in the title, keywords, and abstract:

> (*"Chief information officer" OR "chief technology officer" OR "Information technology Director" OR "IT director" OR "ICT Director" OR "information technology manager" OR "IT manager" OR "ICT manager" OR "IT management" OR "ICT management" OR "information and communications technology management" OR "information technology management" OR "IT alignment" OR "information technology alignment" OR " business-IT alignment" OR "business-ICT alignment" OR "Business/IT alignment" OR "information technology strategy" OR "IT strategy" OR "ICT strategy" OR " information technology governance" OR "IT governance" "IT corporate governance" OR "ICT governance" OR "ICT service management" OR "information technology service management" OR "IT service management" OR "IT process management" OR "IT infrastructure management" OR "ICT infrastructure management" OR "social media management" OR "IT financial management" OR "IT project management" OR "information technology project management"*).

The search retrieved 929 documents from 351 journals from 1986 to 2014. In total, 1,879 authors from 914 institutions and 64 countries authored the documents. However, the WoS data is prone to name anomalies that may affect the network's overall structure. For example, "Lutman J." sometimes appeared as "Lutman, JN". Thus, we checked all the 1,913 author names and corrected 34 anomalies, which left the final author account at 1,879 authors. The document included 780 (87.35%) journal papers, 62 (6.94%) conference proceedings papers, 42 (4.70%) editorials, 28 (3.14%) reviews, 20 (2.24%) book reviews, 10 (1.12) news items, five (0.56%) meeting abstracts, five (0.56%) letters, and two (0.22%) corrections. Figure 1 shows the numbers of publications by year. We could not retrieve a full record of the 36 papers published before the year 1995, so we included a total of 893 papers published during the 1995-2014 period in the network analysis. Table 2 shows the top 20 sources 2. However, note that Table 2 does not account for the fact that some journals publish more total papers in general than others (e.g., *I&M* is on the top of the list, but *I&M* also publishes more papers regularly than other journals).

3.2 Tools and Analysis

No single software program can perform all the different types of analyses we conducted (e.g., constructing networks, structure holes analysis, network visualization, and burst detection). Furthermore, some programs can produce better visualizations for large networks (Science of Science Tool), whereas other software produces better network statistics (e.g., Pajek). Thus, we used several tools to construct and analyze the knowledge and semantic networks. We used Pajek (Nooy, Mrvar, & Batagelj, 2005) to analyze the structural holes and hubs present in the network. We used NodeXL (Smith et al., 2010) to visualize the institution- and country-level networks because one can easily operate it and readily import Pajek output files into it for further analysis. However, NodeXL does not provide good visualizations for large networks; therefore, we used the Science of Science tool (Sci2Team, 2009) to visualize and analyze the large author network. We used the VOSviewer (Van Eck & Waltman, 2010) to construct the journal bibliographic coupling because it provides an easy way to construct and visualize the networks directly from the WoS data. None of the software discussed above provides a way to construct country-level networks from the WoS data; therefore, we used the IntColl.exe routine for constructing country-level collaboration (available at http://www.leydesdorff.net/software.htm).

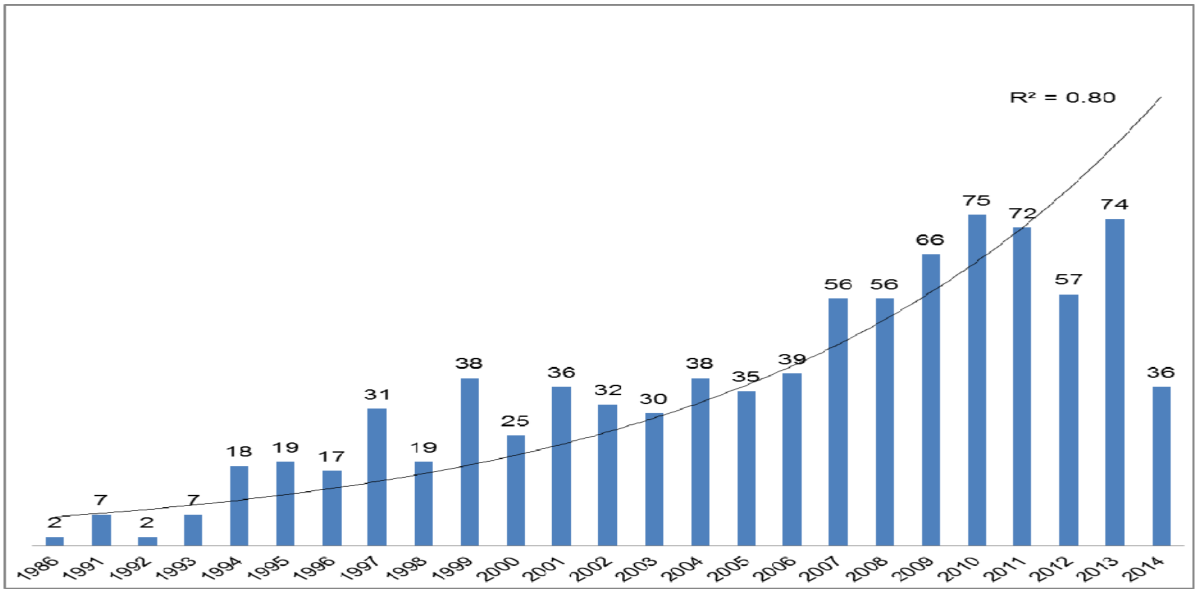

Figure 1. The Number of Publications by Year

Table 2. Top 20 Sources Publishing ITM Research

Source titles	Records	% of 893
Information & Management	39	4.367
Information Systems Management	36	4.031
Journal of Strategic Information Systems	27	3.024
MIS Quarterly	23	2.576
Journal of Computer Information Systems	23	2.576
International Journal of Information Management	21	2.352
Journal of Management Information Systems	20	2.24
Wirtschaftsinformatik	18	2.016
Journal of Information Technology	18	2.016
European Journal of Information Systems	18	2.016
Lecture Notes in Computer Science	17	1.904
Industrial Management Data Systems	16	1.792
Harvard Business Review	16	1.792
IEEE Transactions on Engineering Management	14	1.568
IBM Systems Journal	14	1.568
Government Information Quarterly	14	1.568
Information Systems Research	11	1.232
Journal of Global Information Technology management	10	1.12
MIQ Quarterly Executive	9	1.008
Decision Support Systems	9	1.008

3.3 Constructing Knowledge Networks

We used SNA tools to construct four types of co-authorships networks: the 1) author network, 2) institution network, 3) country network, and 4) source co-citation network. Author networks form when the authors (or nodes in network terms) published in journals establish co-authorship relationships (or links in the network terms). The author network is useful in revealing hidden network structures of scientific collaborations among individual researchers (Liu, Bollen, Nelson, & Van de Sompel, 2005). Institution networks form when institutions that publish papers in journals form co-authorship ties. These networks help one understand knowledge flow among institutions (Swar & Khan, 2013). Country networks form when countries (or nodes) co-publish research in journals and form co-authorship ties (or links). By studying co-authorship relationships among countries, one can investigate the knowledge flow that exists among nations (Kham & Park, 2013). Source co-citation networks form when papers co-cite sources (e.g., journals and conferences) (or nodes) in their reference sections. One uses these networks to study relationships and similarities among sources (Ding et al., 2000; Tsay, Xu, & Wu, 2003). One constructs the source bibliographic coupling network based on the references sources share.

3.4 Properties Measured

Previous studies that took a network perspective on the IS research domain such as Xu and Chau (2006), Vidgen, et al., (2007), and Trier and Molka-Danielsen (2013) predominantly investigate knowledge domains' core network-level properties (such as components, diameter, density, the clustering co-efficient, and average degree) and the node-level properties (degree, betweenness, eigenvector, centralities, structural holes and hubs). These properties can provide a good understanding of both the network as a whole and the network at the specific node level; thus, we also report these properties. We used the network-level properties to study the overall network status of the ITM domain. These network-level properties we measured included components, diameter, density, clustering co-efficient, and average degree. We used the node-level properties to study the position of individual nodes in the network: properties included degree, betweenness, eigenvector, centralities, structural holes, and hubs. Below we explain each of the parameters.

3.4.1 Network-level Properties

A network component is the isolated subnetwork (i.e., it does not connect to any other subnetwork in the network) in which nodes connect to one another (Hanneman & Riddle, 2005). In other words, in a connected component, all nodes are reachable, but the network component is disconnected (i.e., there is no path) from the other components in the network (Wasserman & Faust, 1994). A network's main or largest component is its core component, which has the largest number of nodes. A network's diameter is the longest of all the available shortest paths between any pair of its nodes (Wasserman & Faust, 1994). The diameter represents the linear size of the network and indicates how long it would take for the information or ideas to pass through the network. A network's density deals with the ratio of links to the number of all possible links in the network, such that a fully connected network, in which each node connects to every other node, will have a density of 1. A network's clustering coefficient is the degree to which nodes in the network tend to cluster together. In terms of the co-authorship network, it indicates that "many of a node's collaborators are willing to collaborate with each other, and it represents the probability that two of its collaborators wrote a paper together." (Barabási et al., 2002, p. 296). Finally, a network's average degree centrality measures the average number of links among the different nodes in the network.

3.4.2 Node-level Properties

A node's degree centrality measures the number of links a node has to other nodes. A node's betweenness centrality relates to its centrality in a network, and one can use it to examine a node's ability to control or facilitate collaboration or flow of information due to its central position in the network (Liu et al., 2005). Eigenvector centrality examines a node's importance in a network based on its connections with other important nodes. In other words, it shows a node's networking ability relative to its relationships with other nodes (Marsden, 2008). Structural holes (Burt, 1992) in a network are associated with an advantage (or disadvantage) of a node's location in the network (Hanneman & Riddle, 2005). For example, a node (e.g., author, institutions, country) connected to other nodes that do not themselves connect to each other mediates them (Nooy et al., 2005). In terms of the co-authorship networks, some authors, institutions, or countries may be better positioned in a network to form co-authorship ties than others. We measured structural holes with the concept of aggregate constraints associated with a tie (Nooy et al., 2005). The aggregate constraint on a node is the sum of the dyadic constraint on all of its ties. For example, in a co-authorship network, node X is constrained by its relationship with node Y to the extent that X does not have many collaboration ties (has few other collaboration ties except that to Y) and X's other alternatives are also tied to Y (Hanneman & Riddle, 2005). Nodes, for example, with higher aggregate constrains (HAC) have fewer opportunities to exploit the structural holes (in this case, forming new collaboration ties) and have less freedom to withdraw from the network (Nooy et al., 2005). And nodes with low aggregate constraints (LAC) have more opportunities to exploit the structural holes (i.e., form collaborative ties with other authors). The nodes with LAC, however, can easily withdraw from the network without jeopardizing the overall network structure. Pajek (the social network analysis software we used to calculate the aggregate constraints) provides aggregate constraints acting on a node in the form of value ranges that represent the lower and higher constraints. The aggregate constraint is a nonnegative number that is usually between 0 and 1 but can be greater than 1. And finally, hubs are the nodes in a network with many connections (e.g., they exhibit high degree and betweenness centrality) and are considered focal points in a network.

4 Results

4.1 Author Network

Figure 2 shows the author network of the ITM domain where nodes (n = 1,879) represent authors and the links among the nodes represent co-authorship relationships. Below, we explain its network- and node-level properties in detail.

4.1.1 Network-level Analysis

Table 3 shows the network-level properties of the author network. Overall, 1,879 authors participated in the network to form 2,983 co-authorship ties. In the network, there were 610 connected components with two or more authors and 178 isolates (i.e., solo authors). The largest connected component comprised only 44 (2.25% of the whole network) authors. Overall, there were five other comparatively large connected components that comprised 40, 34, 26, 19, and 17 authors, respectively. The average degree (i.e., the average number of co-authors a person has published with) was 3.14, the density was 0.002, the diameter was 7.0, and the average clustering coefficient was 0.63. From the analysis, we can conclude that the network was fragmented with several isolated clusters of authors working in silos. And the network did not contain one large core community of authors unlike other information systems communities.

4.1.2 Node-level Properties

Table 3 shows the node-level properties of the network. Table 4 shows the top 20 authors in terms of the degree centralities, structural holes, and hubs. In terms of the structural holes, the analysis revealed that there were at least 125 (6.53% of the whole network) authors with the lowest aggregate constraints (LAC) that ranged from 0.14 to 0.39 (Table 3). Table 3 shows the top 20 LAC values. Also, 1,227 (64.11%) authors had the highest aggregate constraints (HAC) that ranged from 0.89 to 1.13. Table 3 shows the top HAC values. One can imagine aggregate constraints as a method of ranking authors on scale of 0 to 1, where the authors with LAC value close to zero (such as Cheung and Matar) are the ones who have more opportunities to exploit the structural holes in the network due to their position in the network. And the authors with HAC value close to 1 (such as Yeh and Davis) are the ones who have less opportunity to exploit the structural holes in the network due to their position in the network. Overall, the results suggest that, in the ITM network, only a handful of authors were positioned to exploit the network (e.g., were well positioned to extend the network and form research ties with other authors), whereas the majority of the authors could not use their position to benefit from the network. Said differently, the majority of the ITM authors could not form collaboration ties with other authors located isolated clusters and could not use their existing network ties to obtain certain advantages (such as information and control advantages) over other the ITM authors (Burt, 1992). However, the results do not suggest that they could not form collaboration ties at all. Even though their position in the network made it more difficult to form ties based on previous co-authorships, the ITM authors could form collaboration ties through means other than previous co-authorships, such as social gatherings and conferences meetings. Further, in terms of degree, the network shows the power law distribution. The higher R-squared (R^2) value shows that the trend line fits the data well (i.e., the degree falls at constantly decreasing rates).

Table 3. Summary of the Knowledge Networks: Network-level Properties

Networks	Nodes/ edges	No. of components	Main component nodes/edges	Density	Average degree	Diameter	Clustering coefficient
Author network	1913/2999	448	43	0.002	3.14	7.0	0.63
Institution network	854/987	124	326	0.003	2.30	18.0	0.36
Country network	61/210	20 (includes 19 isolates)	42	0.57	3.44	5.0	0.34

Table 4. Top 20 Authors in Terms of Centralities, Hubs, and Structural Holes

Degree	Betweenness	Eigenvector	Hubs	LAC	HAC
Cheung, J	Matar, F	Cheung, J	Cheung, J	Cheung, J	Yeh, SP
Sailer, A	Sambamurthy, V	Sukhram, M	Roehrl, MHA	Matar, F	Davis, L
Sukhram, M	Bharadwaj, A	Michaelson, T	Michaelson, T	Sailer, A	Kroon, V
Michaelson, T	Sailer, A	Son, V	Sukhram, M	Keil, M	Fisher, MA
Son, V	Pavlou, PA	Slavine, I	Son, V	Qazi, N	Moss, S
Slavine, I	Luftman, J	Shaw, S	Slavine, I	Michaelson, T	Yeh, CH
Shaw, S	Draper, C	Meng, F	Shaw, S	Shaw, S	Bhattacherjee, A
Meng, F	Cheung, J	Liang, SB	Meng, F	Disney, G	Powell, B
Liang, SB	Grover, V	Kwok, R	Liang, SB	Amin, N	Mark, K
Kwok, R	Zmud, RW	Jiang, J	Kwok, R	Sukhram, M	Radhakrishnan, R
Jiang, J	Ward, C	Dookhie, T	Jiang, J	Son, V	Haufe, K
Dookhie, T	Karagiannis, D	Chasmar, M	Dookhie, T	Slavine, I	Dzombeta, S
Chasmar, M	Miller, BA	Cardoso, M	Chasmar, M	Begley, H	Thong, JYL
Cardoso, M	Cheung, C	Amin, N	Cardoso, M	Chadwick, D	Chan, FKY
Amin, N	Richardson, VJ	Ali, A	Amin, N	Cardoso, M	Venkatesh, V
Ali, A	Carter, M	Alam, A	Ali, A	Roehrl, MHA	Sun, J
Alam, A	Martinsons, MG	Qazi, N	Alam, A	Alam, A	Jamjoom, H
Qazi, N	Keil, M	Disney, G	Qazi, N	Ali, A	Brandis, K
Disney, G	Bartolini, C	Begley, H	Disney, G	Dookhie, T	Qu, HL
Begley, H	Chatterjee, D	Chadwick, D	Begley, H	Chasmar, M	Khan, A

The results from Table 4 rank the top 20 authors in terms of centralities, hubs, and structural holes. In terms of degree, Cheung had the highest number of connections with other authors in the network. Despite not ranking at the top for betweenness, his high eigenvector and LAC placements demonstrate both his strong connections to other important ITM scholars and his ability to exploit his position in the network (form collaboration ties with other authors for example). In contrast to this, Matter, while being well positioned to take advantage of the network position by way of a high LAC rank, could not take advantage of this rank due to a failure to secure strong network connections with other important authors.

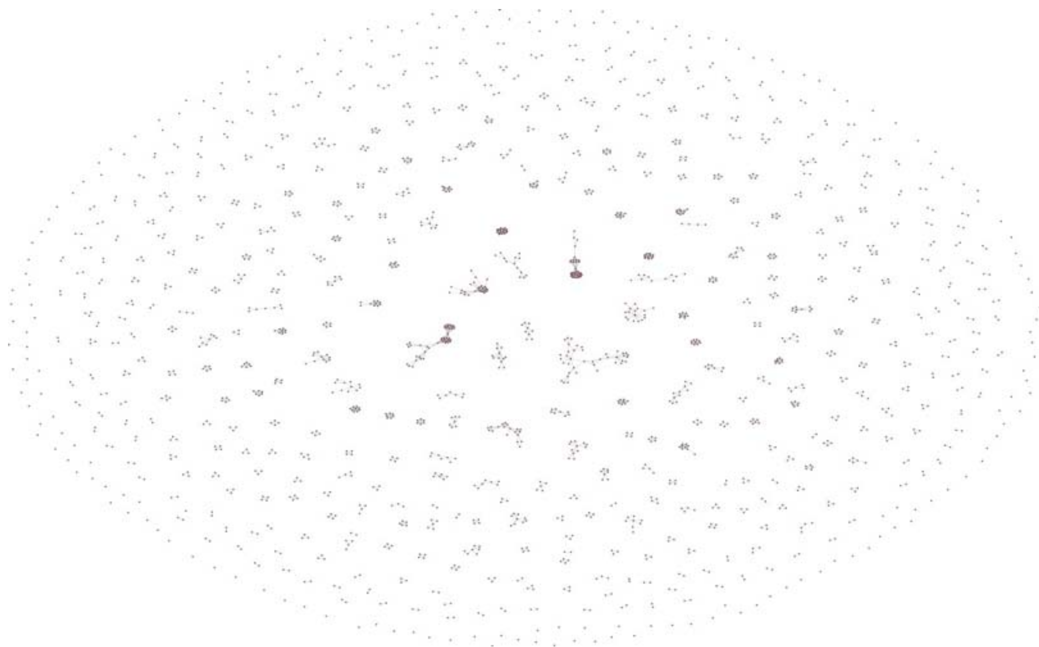

Figure 2. Authors Collaboration Network 1995-2014 (N = 1913; 893 documents)

4.2 Institutions Network

Figure 3 shows the institutional-level network. In the figure, the nodes represent institutions and links that represent co-authorship ties. Node size represents betweenness centrality. The figure gives titles to the top 20 nodes with the highest level of betweenness centrality. Link width demonstrates the strength of collaboration.

4.2.1 Network-level Analysis

Table 3 shows the network-level properties of the institutions network. Overall, 854 institutions participated in the network to form 987 co-authorship ties. The network had 124 connected components (with at least two nodes) and 170 isolates (i.e., publishing institutions that had no co-authorship ties with other institutions). The largest connected components comprised 326 institutes (37.99%) and the second largest components comprised 10 institutions. The average degree (i.e., the average degree is the average number of co-authors a person has published) was 2.30, the density was 0.003, the diameter was 18, and the average clustering coefficient was 0.36.

4.2.2 Node-level Analysis

Table 5 shows the top 20 institutions in terms of the degree centralities, structural holes, and hubs. In terms of the structural holes, the analysis revealed that the network had at least 83 (7.92% of the whole network) institutions with the lowest aggregate constraints that ranged from 0.09 to 0.23. Table 5 shows the top 20 lowest aggregate constraint values. Also, 271 (31.73%) institutions had medium-to-high level aggregate constraint values that ranged from 0.37 to 0.92. There were 504 (59.01%) institutions with very high aggregate constraints with values ranging from 0.92 to 1.33. Table 5 shows the top 20 institutions with the highest aggregate constraints. Overall, the network results suggest that only a few institutions (7.92%) were positioned well to exploit the network and that the majority (59.01%) could not use their position to benefit from the network. Further, in terms of degree, the network shows that the power law distribution existed in it. The higher R-squared (R^2) value shows that the trend line fits the data well (i.e., the degree fall at constantly decreasing rates).

Table 5. Top 20 Institutions in Terms of Degree Centrality, Hubs, and Structural Holes

Degree (the number of links a node has to other nodes)	**Betweenness** (the centrality of a node in a network)	**Eigenvector** (the importance of a node in a network based on its connections with other important nodes)	**Hubs** (the nodes in a network with many connections and are considered focal points in a network)	**LAC** (nodes that have more opportunities to exploit the structural holes in a network)	**Degree** (the number of links a node has to other nodes)
University of Maryland	Georgia State University	University of Gottingen	University of Kentucky	University of Maryland	University of Maryland
Georgia State University	Arizona State University	University of Vienna	Miami University	Georgia State University	Georgia State University
IBM Research Division	Huazhong University of Science & Technology	University of St Gallen	Georgia State University	Florida State University	IBM Research Division
Florida State University	City University of Hong Kong	University of Zurich	University of Georgia	University of North Carolina	Florida State University
University of North Carolina	University of Maryland	University of Kassel	Texas Christian University	Arizona State University	University of North Carolina
University of Gottingen	University of North Carolina	Technical University of Berlin	Kentucky State University	University of Nebraska	University of Gottingen
Arizona State University	Hong Kong Polytech University	Stanford University	Georgia Gwinnett College	City University of Hong Kong	Arizona State University
University of Vienna	Michigan State University	Hasso Plattner Institute	University of South Florida	Michigan State University	University of Vienna
University of Georgia	National University of Singapore	Ftm Frankfurt Technology Management Gmbh	Baylor University	University of Minnesota	University of Georgia
MIT	Emory University	Arizona State University	Emory University	IBM Research Division	MIT
IBM Global Technology Service	IBM Corporation	IBM Corporation	Arizona State University	University of Arkansas	IBM Global Technology Service
IBM Corporation	Florida State University	University of Munich	North Carolina Agriculture &Technology State University	University of Alabama	IBM Corporation
University of Texas Dallas	University of Vienna	University of Giessen	Florida State University	Monash University	University of Texas Dallas
Monash University	University of Minnesota	Kompetenznetz Parkinson	University of Missouri	Emory University	Monash University
Michigan State University	University of Melbourne	IBM Enterprise Business Information Center of Excellence	Michigan State University	University of Georgia	Michigan State University
Texas Agricultural and Mechanical University	Florida International University	Deutsch Telekom AG	University of North Texas	University of Colorado	Texas Agricultural and Mechanical University
University of St Gallen	University of Georgia	University of Minnesota	University of Alabama	University of Oklahoma	University of St Gallen
University of Minnesota	University of Utrecht	IBM Research Division	Huazhong University of Science & Technology	IBM Corporation	University of Minnesota
University of Tennessee	IBM Research Division	New York University	Louisiana State University	Hong Kong Polytech University	University of Tennessee
University of Oklahoma	University of Alabama	University of Rochester	UnivNevada	University of New South Wales	University of Oklahoma

The results from Table 5 ranks the top 20 institutions in terms of their degree centrality, hubs, and structural holes. Given their high respective rankings, the results show that the Universities of Maryland and Georgia State had high levels of network interconnectivity and linkages with other universities. This finding demonstrates their ability to be positioned at the center of the network and, as a result of this placement, influence the spread of information that flows through it. While the LAC rankings for the Hong Kong Polytech University and the University of New South Wales show that they were poorly connected and placed to exploit any network opportunities.

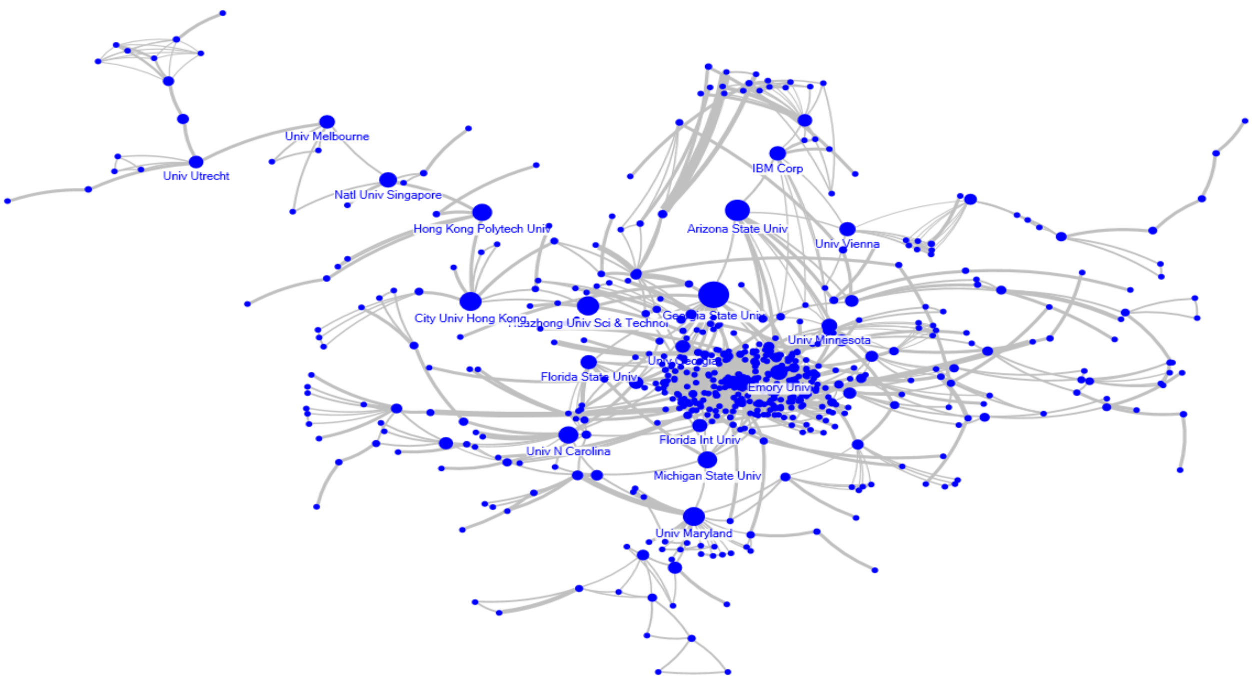

Figure 3. ITM Institutional Collaboration Network

4.3 Country Network

In the country-level network (see Figure 4), nodes represent countries and links represent collaboration ties. In this instance, node size represents betweenness centrality, and link width represents intensity of collaboration. As one can see from the top 20 countries in Table 6, in terms of degree, the USA had the highest number of connections with other countries in the network. It also ranked number one for betweenness, egivenvector, and LAC scores. This result demonstrates the centrality or closeness of the country in the network to other institutions and its control over the flow of information in the network. The results also show that the USA was well connected to other important countries in the network such as India, China, and the UK. When comparing its degree rankings with that of its LAC scores, one can see that the USA was well positioned to exploit its position in the network. Spain and the Netherlands were also well positioned to take advantage of the network position; however, due to their poor degree ranking, they failed to attain any really benefit from the network.

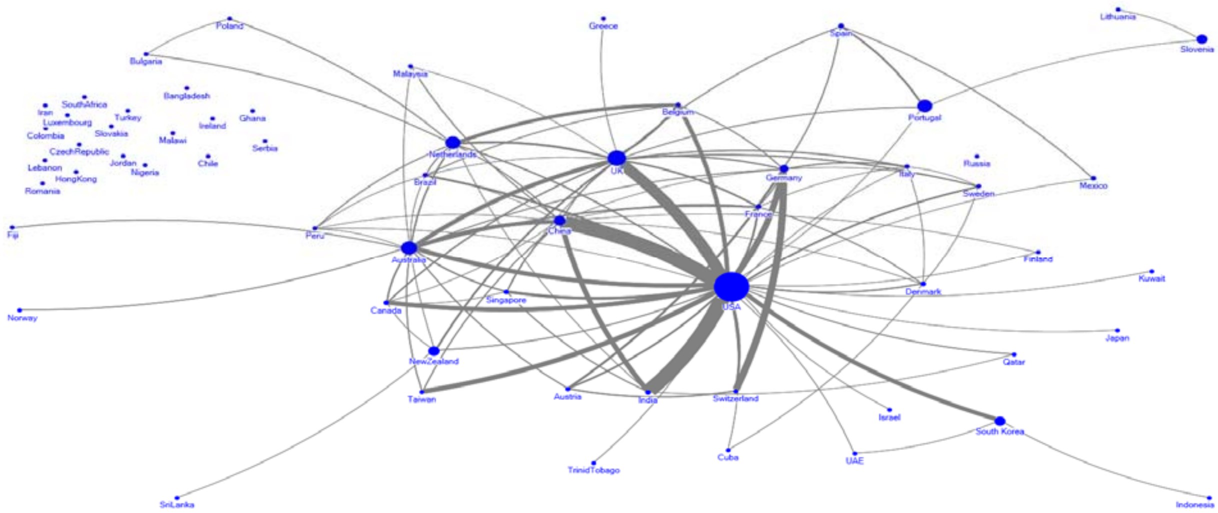

Figure 4. ITM Institutional Collaboration Network

Table 6. Top 20 Countries in Terms of Degree Centralities and Structural Holes

Degree	Betweenness	Eigenvector	LAC
The USA	The USA	The USA	The USA
The UK	The UK	The UK	Spain
China	Australia	China	The Netherlands
Australia	Netherlands	Australia	The UK
Germany	Portugal	Germany	Germany
The Netherlands	China	The Netherlands	Australia
France	New Zealand	France	Denmark
Brazil	South Korea	Brazil	Peru
Singapore	Slovenia	Singapore	France
Italy	Germany	Canada	Portugal
Denmark	Spain	Italy	Malaysia
Canada	India	Peru	Italy
New Zealand	Canada	Belgium	Belgium
India	Mexico	Denmark	Slovenia
Sweden	Denmark	Sweden	Brazil
Belgium	France	India	NewZealand
Peru	Singapore	Austria	Sweden
Portugal	Brazil	Taiwan	Mexico
Spain	Austria	New Zealand	Austria
Austria	Italy	Portugal	China

4.4 Source Networks

4.4.1 Source Bibliographic Coupling Network

Bibliographic coupling is based on the references sources share. Out of the 351 outlets, we included only the outlets with at least five publications (n = 37) in the bibliographic coupling analysis. In Figure 5, nodes represent journals, and any links drawn among the nodes reflect whether or not they share references. Node size represents the number of documents analyzed for each source. For visibility reasons, we reduced the numbers of links (we show only 500 links), trimmed labels, and do not show the overlapping node labels. Node color indicates clustering groups. Based on the bibliographic coupling, we grouped the 37 journals into eight clusters. Node color indicates clustering groups. For example, cluster 1 (dark yellow nodes) included two journals: *MIS Quarterly* and *Journal of Association for Information Systems*. Cluster 2 (sky blue nodes) included three journals: *Journal of Information Technology, Journal of Information Systems and Technology Management*, and *Revista de Administração Contemporânea*. Cluster 3 (cyan nodes) included three journals: *Information Systems Research*, *Journal of Strategic Information Systems*, and *Research-Technology Management*. Similarly, cluster 4 (magenta nodes) included three journals: *Information & Management*, *European Journal of Information Systems*, and *International Journal Technology Management*. Cluster 5 included four journals: *Journal of Management Information Systems*, *Decision Support Systems*, *IEEE Transection on Engineering Managemen*t, and *Harvard Business Review*. Cluster 6 (blue nodes) included five journals: *Journal of Computer Information Systems*, *Journal of Global Information Technology Management*, *Journal of Global Information Management*, *Journal of Information Systems Frontier*, and *International Journal of Production Management*. Cluster 7 (green nodes) included eight journals: *Information Systems Management*, *Information Systems Journal, Government Information Quarterly*, *International Journal of Information Management*, *Industrial Management and Data Systems*, *IBM Systems Journal*, *Communications of ACM*, and *Project Management Journal*. Similarly, cluster 8 (red nodes) included eight journals: *MIS Quarterly Executive*, *Business and Information Systems Engineering, Information Technology and Management, Journal of Network and Systems Management, Methods of Information in Medicine, International Journal of Medical Informatics, Healthcare Management Review,* and *Wirtschaftsinformatik*.

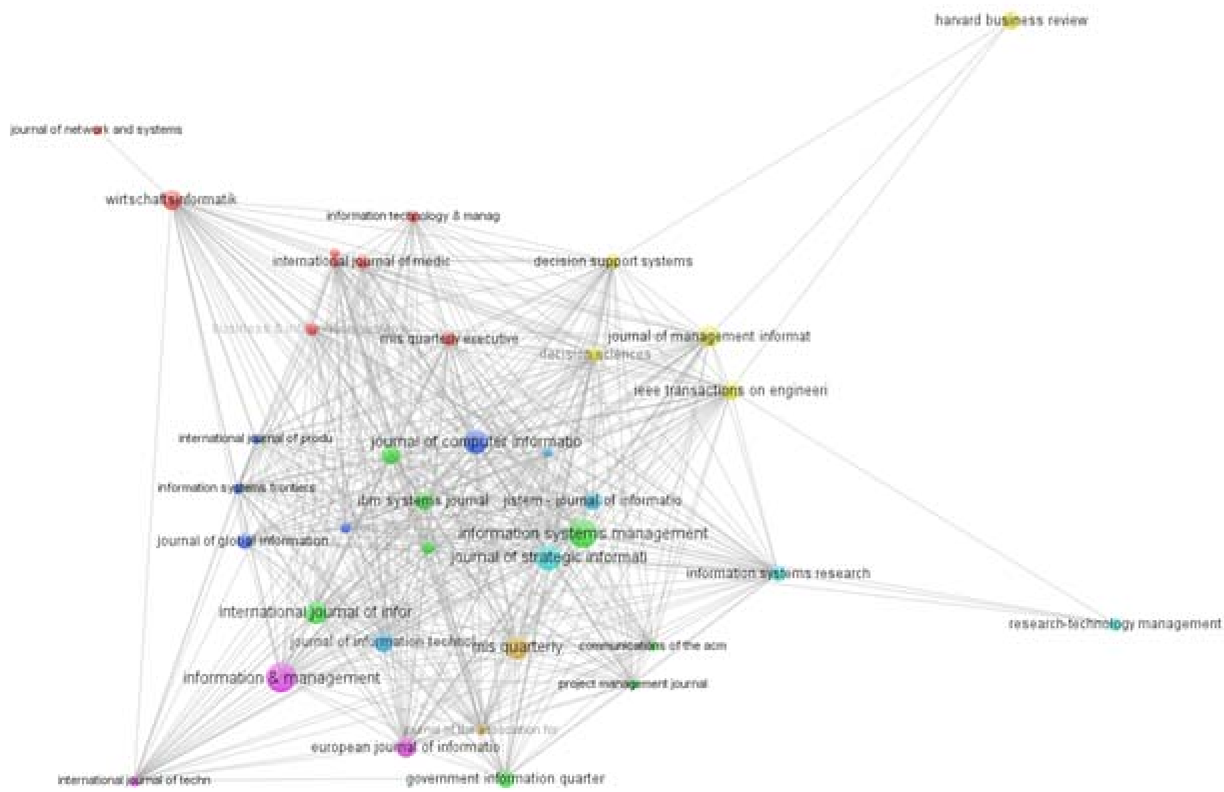

Figure 5. Bibliographic Coupling of the ITM Journals

4.4.2 Sources Co-occurrence Network

The source co-occurrence network is established based on the source co-appearing in the reference sections of the articles (Figure 6). Out of the total sources cited in reference section (n = 11,413), we included only those sources cited at least 20 times (n = 165) in the analysis. Figure 6 shows the sources co-citation results: the nodes are the journals and links represent co-citation among journals. Node size shows the number of co-citations: a node is bigger if it was co-cited more frequently. For visibility, we reduce the numbers of links (we show only 700 links), trim labels, and do not show the overlapping node labels. Node color indicates clustering groups.

Based on co-citation sources, we clustered the results into seven groups. We list the most prominent journals in each cluster. Cluster 1 (red nodes) included *MISQ, Harvard Business Review*, *Communications of ACM*, *Information & Management*, *Journal of Management Information Systems*, and *Sloan Management Review*. Cluster 2 (purple nodes) included *Information Systems Research, Management Science,* and *Decision Science*. Cluster 3 (yellow nodes) included *Strategic Management Journal*, *Academy Management Review*, *Organization Science*, and *Administration Science Quarterly*. Cluster 4 (sky blue nodes) included *European Journal of Information Systems*, *Journal of Management Information Systems*, *Journal of Strategic Information Systems*, and *Information Systems Journal*. Green node journals included *IBM Systems Journal*, *MISQ Executive*, *Information System Management*, *Information & Management*, *Journal of Information Technology*, and others. One can see the other clusters in the Figure 6. Table 7 shows the top 20 journals in terms of network properties and co-citations. The network-level properties indicate that, in terms of degree, betweenness, and eigenvector, the *MIS Quarterly*, *Information Systems Research*, *Strategic Management Journal*, and *CACM* were the most influential journals and the central key players in terms of quality of information flow in the network.

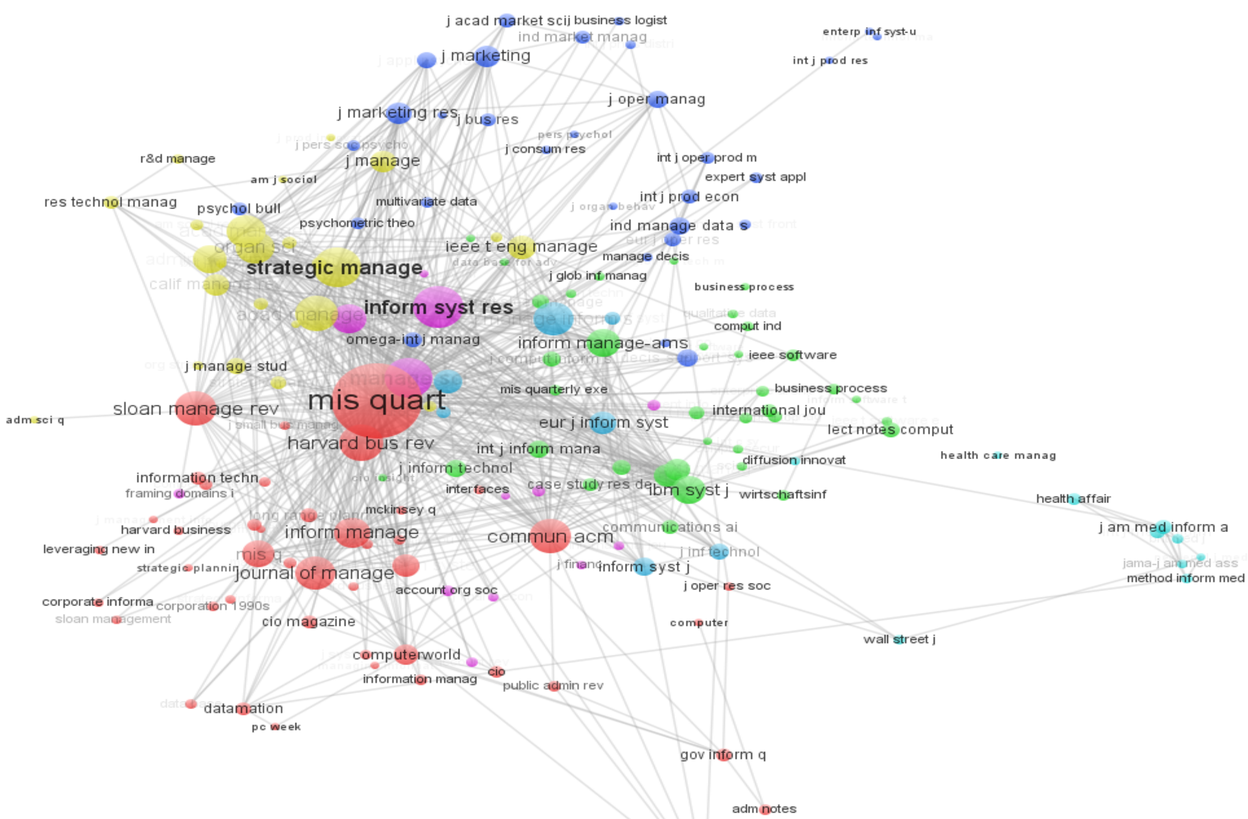

Figure 6. Source (Appearing in the Reference Section) Co-citation Network (N = 165; No. of Documents = 893)

4.5 Citation Analysis

The 929 papers analyzed received a total of 10,681 citations or 9,608 if one adjusts for self-citations. A total of 7,325 papers cited these papers. The average citations per paper was 11.50 citations and the h-index was 48 (i.e., 48 papers were cited at least 48 times) (Table 8 shows the top 30 cited papers). The number of citations has increased over time (Figure 7).

Table 7. The Top 20 Sources Co-citation Based on Strength

Degree	Betweenness	Eigenvector	Page rank	Co-citation
MISQ	*MISQ*	*MISQ*	*MISQ*	*ISR; MISQ*
CACM	*DSS*	*MS*	*MS*	*MISQ; SMJ*
MS	*CACM*	*CACM*	*CACM*	*MS; MISQ*
ISR	*MS*	*ISR*	*ISR*	*MISQ; SMR*
SMR	*SMJ*	*SMR*	*SMJ*	*JMIS; MISQ*
OR	*ISR*	*JMIS*	*ISM*	*HBR; MISQ*
HBR	*IM*	*DS*	*JMIS*	*JMIS; MISQ*
IM	*HBR*	*ISM*	*SMR*	*MISQ; OS*
AMR	*OS*	*IM*	*DS*	*AMR; MISQ*
JMIS	*IBMSJ*	*AMR*	*IM*	*IM; MISQ*
SMJ	*IEEETEM*	*HBR*	*IEEETEM*	*DS; MISQ*
DS	*SMR*	*SMJ*	*HBR*	*CACM; MISQ*
ASQ	*JMIS*	*IEEETEM*	*AMR*	*AMJ; MISQ*
IEEETEM	*AMR*	*OS*	*ASQ*	*ASQ; MISQ*
IBMSJ	*ASQ*	*AMJ*	*OS*	*ISR; SMJ*
AMJ	*CW*	*ASQ*	*DSS*	*ISR; MS*
IS	*IM*	*EJIS*	*AMJ*	*JSIS; MISQ*
JSIS	*DS*	*IBMSJ*	*IBMSJ*	*IEETEM; MISQ*
IBMSJ	*ISM*	*DSS*	*IS*	*IBMSJ; MISQ*
IS	*MISQE*	*IS*	*EJIS*	*MISQ; SMR*
EJIS	*AMJ*	*JM*	*MISQE*	*EJIS; MISQ*

Legend: *MIS Quarterly* (*MISQ*)*; Information Systems Research* (*ISR*)*; Decision Support Systems* (*DSS*)*; Strategic Management Journal* (*SMJ*)*; Management Science* (*MS*)*; Communication of ACM* (*CACM*)*; Sloan Management Review* (*SMR*)*; Strategic Manage Journal* (*SMJ*)*; Organization Science* (*OS*)*; Journal of Management Information Systems* (*JMIS*)*; Harvard Business Review* (*HBR*)*; Information & Management* (*IM*)*; The Academy of Management Review* (*AMR*)*; IBM Systems Journal* (*ABMSJ*)*; IEEE Transactions on Engineering Management* (*IEEETEM*)*; Decision Science* (*DS*)*; Administrative Science Quarterly* (*ASQ*)*; Information Systems* (*IS*)*; Journal of Strategic Information Systems* (*JSIS*)*; California Manage Review* (*CMR*)*; European Journal of Information Systems* (*EJIS*)*;* Computerworld (CW); *Journal of Management* (JM).

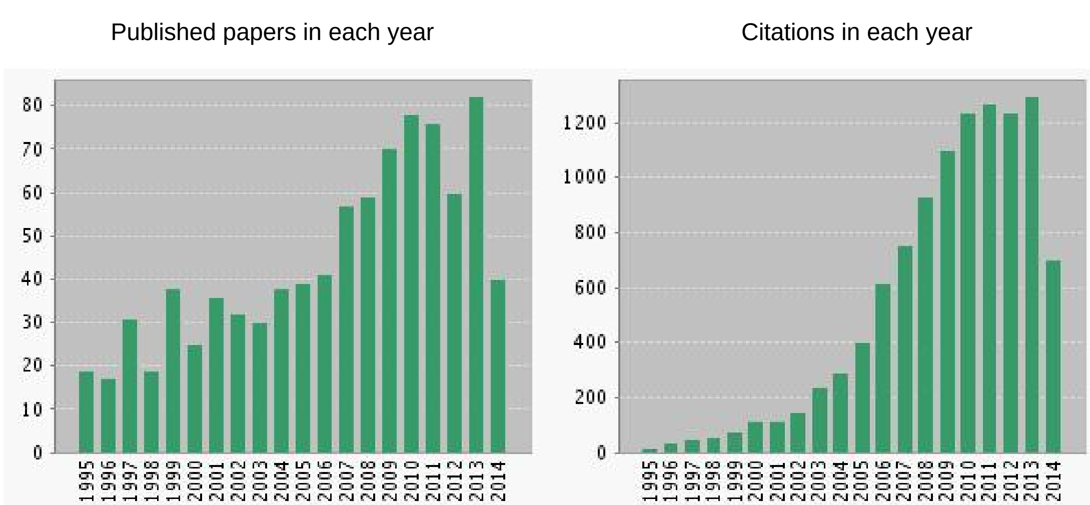

Figure 7. Publications and Citation Received by Year by ITM studies (1995-2014)

Table 8. The Top 30 Most Cited Papers

Paper	Citations
Sambamurthy, V., Bharadwaj, A., & Grover, V. (2003). Shaping agility through digital options: Reconceptualizing the role of information technology in contemporary firms. *MIS Quarterly, 27(*2), 237-263.	452
Henderson, J. C., & Venkatraman, H. (1993). Strategic alignment: Leveraging information technology for transforming organization. *IBM Systems Journal, 32*(1), 4-16.	403
Hu, P. J., Chau, P. Y. K., Sheng, O. R. L., & Tam, K. Y. (1999). Examining the technology acceptance model using physician acceptance of telemedicine technology. *Journal of Management Information Systems*, *16*(2), 91-112.	366
Carr, N. G. (2003). IT doesn't matter. *Harvard Business Review.* Retrieved from https://hbr.org/2003/05/it-doesnt-matter	326
Hong, K. K., & Kim, Y. G. (2002). The critical success factors for ERP implementation: An organizational fit perspective. *Information & Management*, *40*(1) 25-40.	257
Tallon, P. P., Kraemer, K. L., & Gurbaxani, V. (2000). Executives' perceptions of the business value of information technology: A process-oriented approach. *Journal of Management Information Systems, 16*(4), 145-173.	235
Armstrong, C. P., & Sambamurthy, V. (1999). Information technology assimilation in firms: The influence of senior leadership and IT infrastructures. *Information Systems Research, 10*(4), 304-327.	236
Boynton, A. C., Zmud, R. W., & Jacobs, G. C. (1994). The influence of IT management practice on IT use in large organizations. *MIS Quarterly*, *18*(3), 299-318.	215
Sambamurthy, V., & Zmud, R. W. (1999). Arrangements for information technology governance: A theory of multiple contingencies. *MIS Quarterly*, *23*(2), 261-290.	202
Chatterjee, D., Grewal, R., & Sambamurthy, V. (2002). Shaping up for e-commerce: Institutional enablers of the organizational assimilation of Web technologies. *MIS Quarterly,* 26(2), 65-89.	198
Broadbent, M., Weill, P., & St. Clair, D. (1999). The implications of information technology infrastructure for business process redesign. *MIS Quarterly, 23*(2), 159-182.	144
Sturdy, A. (1997). The consultancy process—an insecure business? *Journal of Management Studies, 34*(3), 389-413.	139
Henderson, J. C., & Venkatraman, H. (1999). Strategic alignment: Leveraging information technology for transforming organizations. *IBM Systems Journal*, *38*(2-3), 472-484.	129
Kearns, G. S., & Lederer, A. L. (2003). A resource-based view of strategic IT alignment: How knowledge sharing creates competitive advantage. *Decision Sciences, 34*(1), 1-29.	116
Chan, Y. E., & Reich, B. H. (2007). IT alignment: What have we learned? *Journal of Information Technology, 22*, 297-315.	111
Luftman, J., & Brier, T. (1999). Achieving and sustaining business-IT alignment. *California Management Review, 42*(1), 109-122.	100
Sabherwal, R., Hirschheim, R., & Goles, T. (2001). The dynamics of alignment: Insights from a punctuated equilibrium model. *Organization Science*, *12*(2), 179-197.	98
Pawlowski, S. D., & Robey, D. (2004). Bridging user organizations: Knowledge brokering and the work of information technology professionals. *MIS Quarterly*, *28*(4), 645-672.	91
Bassellier, G., Reich, B. H., & Benbasat, I. (2001). Information technology competence of business managers: A definition and research model. *Journal of Management of Information Systems*, *7*(4), 159-182.	86
Tanriverdi, H. (2006). Performance effects of information technology synergies in multibusiness firms. *MIS Quarterly*, *30*(1), 57-77.	85
Karreman, D., & Alvesson, M. (2004). Cages in tandem: Management control, social identity, and identification in a knowledge-intensive firm. *Organization, 11*(1), 149-175.	84
Luftman, J., Lewis, P., & Oldach, S. (1993). Transforming the enterprise: The alignment of business and information technology strategies. *IBM Systems Journal*, *32*(1), 198-221.	85
Avison, D., Jones, J., Powell, P., & Wilson, D. (2004). Using and validating the strategic alignment model. *The Journal of Strategic Information Systems*, *13*(3), 223-246.	83

Table 8. The Top 30 Most Cited Papers

Jasperson, J. S., Carte, T. A., Saunders, Carol, S., Butler, B. S., Croes, H., & Zheng, W. (2002). Review: Power and information technology research: A metatriangulation review. *MIS Quarterly, 26*(4), 397-459.	82
Sambamurthy, V., & Zmud, R. W. (2000). The organizing logic for an enterprise's IT activities in the digital era—a prognosis of practice and a call for research. *Information Systems Research, 11*(2), 105-114.	78
Bergeron, F., Raymond, L., & Rivard, S. (2004). Ideal patterns of strategic alignment and business performance. *Information Management, 41*(8), 1003-1020.	76
Segars, A. H., & Grover, V. (1999). Profiles of strategic information systems planning. *Information Systems Research, 10*(3), 199-232.	75
Marcus, M. L. (2004). Technochange management: Using IT to drive organizational change. *Journal of Information Technology, 19*(1), 4-20.	74
Chatterjee, D., Richardson, V. J., & Zmud, R. W. (2001). Examining the shareholder wealth effects of announcements of newly created CIO positions. *MIS Quarterly*, *25*(1), 43-70.	74
Southon, G., Sauer, C., & Dampney, K. (1999). Lessons from a failed information systems initiative: issues for complex organisations, *International Journal of Medical Informatics*, 55(1), 33-46.	71

5 Discussion

By employing the social network analysis technique, we decomposed the semantic and knowledge networks of the ITM domain. We investigated the networked knowledge infrastructure at five levels: author, institution, journal, country, and keyword. In this section, we discuss the main findings (see Table 9).

5.1 Authors and Institutional Networks

The author network analysis showed that the network was fragmented with several isolated clusters of authors working in silos. We found the network did not contain one large core community of authors unlike the other information systems communities whose co-authorship networks are dominated by a core component (Trier & Molka-Danielsen, 2013; Vidgen et al., 2007; Xu & Chau, 2006). We found that the diameter of the co-authorship network was relatively small and that the clustering co-efficient was high. This finding implies that the ITM network exhibited the small-world phenomenon (Watts & Strogatz, 1998), which suggests that the authors contributing in the domain had a high tendency to form groups. Some other information systems communities have reported a similar tendency (Xu & Chau, 2006). Unlike the author network, the institutional network was well formed with the largest connected components comprising 326 institutes. Also, the diameter of the network was large and the clustering co-efficient was low. These findings indicate several things. First, the network did not exhibit the small-world phenomenon, which suggests that the institutions have a low tendency to form groups. Similarly, the structural holes analysis suggests that only a handful of institutions (7.92%) were well positioned to exploit the network, whereas the majority of the institutions (59.01%) could not use their position to benefit from it. The literature contains strong support for network position and organizational research performance (Ahuja, 2000; Lee, Seo, Choe, & Kim,, 2012). Lee et al. (2012), for example, in studying Korean research institutes, show that the most productive institutes are the ones that maintain a cohesive network position forging intensive ties with their collaborators.

The structural irregularity in the networks (i.e., the author network was fragmented and the institutional network was both well formed and contained a large core) points to an interesting phenomenon. This structural irregularity suggests that either: 1) there are several distinct subfields that do not collaborate but that are often in the same institution or 2) that there are several distinct schools of thought that pursue different hypotheses but that are often in the same department. The second option can be a characteristic of an emerging field that has yet to settle on a paradigm. Such a phenomenon leads to a network structure similar to the one we observed with a fragmented author-level network and well-formed institutional-level network. To further investigate this phenomenon, we dug deeper into the publications data and observed that several distinct authors from the same institutions existed but that they did not often collaborate. This finding suggests that the ITM community comprises individuals that pursue several distinct schools of thoughts that pursue different hypotheses, that belong to the same institutions, but that do not collaborate. However, we note that such network irregularities may not necessarily form due to different schools of thoughts in a domain. Certain authors may not collaborate for many other (political, personality-related, organizational, etc.) reasons. Thus, future research should further investigate whether the ITM community does, in fact, comprise several different schools of thought by using deeper content or co-citation network analyses to investigate the causes of the network's fragmentation.

Our structural holes analysis revealed that, in the ITM co-authorship network, only a handful of authors were well positioned to exploit the network; the majority of the authors could not use their position to benefit from it. In other words, the majority of the ITM authors could not form collaboration ties with other authors located in multiple disconnected network clusters and could not use their existing network connections to obtain certain advantages (such as information and control advantages) over other ITM authors (Burt, 1992). The abundance of structures holes in the ITM network seemed to coexist with the preferential attachment phenomenon observed in the network. We found that, in terms of the degree, the network showed the power law distribution in which the new nodes and links attached preferentially to the nodes (e.g., authors, institution, countries, and keywords) already well placed and in a position of real importance in the network.

The preferential attachment may be an optimal strategy for the new incoming ITM authors to quickly forge collaboration ties with the established authors. However, the key question remains about the ITM domain's overall health. Is it in a good or bad condition? For example, if a new incoming author chooses to collaborate with a well-established author in their area of expertise, the diversity of the collaboration, topic, and issues being discussed may be limited. Limited diversity, for example, may also affect the research performance of the ITM authors because collaboration diversity is positively linked to research output and performance (Guan, Yan, & Zhang, 2015). Researchers have previously raised the question of diversity of IS research domains (Rowe, 2012), and some researchers argue that IS research contains a healthy level of diversity in terms of its research themes, new knowledge, methodologies, and citation patterns (Benbasat & Weber, 1996; Bernroider, Pilkington, & Cordoba, 2013; Rowe, 2012). However, questions about diversity should focus not only on the eminent genre but also the network arrangements of nations, institutions, journals, and authors.

5.2 Country-level Network

From a country-level network analysis perspective, the degree, betweennness, eigenvector, and LAC results showed that the USA, the UK, and, to a lesser extent, Australia, India, and China were key players in the network. As Figure 4 highlights, the USA performed the role as the primary hub in the network, with much of the collaboration occurring between the USA, UK, China, and India. The results also highlight the large number of countries[1] that work independently in the ITM domain with no connectivity to other players in the network, such as Ireland—surprising given its level of economic development and the relative strength of its IT sector. Moreover, the majority of developing countries did not participate in the collaboration network. Of those that did, China and India had a relatively strong relationship in the network. We did, however, find it encouraging to see countries such as Brazil, Peru, and Mexico demonstrate the ability to conduct independent research. Despite this fact, such solo research may well mean that the involved institutions miss out on advanced knowledge and experience that interaction with developed countries could provide. In summary, these results point to a potential lack of ITM understanding among developing nations and a need for them to become more active participants in the network. However, alternatively, it may also be representative of the fact that fewer research universities, research resources, and researchers exist in general in these areas. The governments of these countries should help to facilitate research and development work in universities to help build both stronger international ties and opportunities for creating more knowledge. However, governments should not necessarily take over or intervene; rather, they should seek to play the role of facilitator to promote ITM in their country. Strong government intervention may actually hamper the development of knowledge infrastructure (Park, Hong, & Leydesdorff, 2005). One also needs to bear in mind that different countries have differing research portfolios, economic situations, and social structures; thus, a particular government policy or intervention that works in country may not work for another.

5.3 Source Network

The source (e.g., journal) bibliographic coupling networks showed that the 37 journals included in the ITM network formed eight distinct clusters (see Figure 6) based on the frequency of references they shared.

[1] Countries not connected to the network in any way include: Iran, Luxembourg, South Africa, Columbia, Czech Republic, Lebanon, Romania, Hong Kong, Jordan, Nigeria, Slovakia, Turkey, Bangladesh, Malawi, Chile, Ireland, Ghana, and Serbia.

For example, the results showed that, if a work is referenced in the *MIS Quarterly,* it is also likely to be referenced in the *Journal of Association for Information Systems*. In terms of the co-citation analysis, the ITM sources were clustered into 7 groups. The results also showed that the *MISQ* was the top co-cited journal and, thus, its high influence in the ITM domain. Scholars consider co-citation as a proxy for intellectual similarity (Small, 1973); hence, we can conclude that, in case of the ITM research, the following sources are intellectually similar in nature: *MIS Quarterly, Harvard Business Review, Communications of ACM, Information & Management, Journal of Management Information Systems,* and *Sloan Management Review*. Thus, one looking for intellectually comparable ITM related research may consult these outlets.

5.4 Implications and Future Research

By examining the ITM domain from a network perspective, we make several key contributions to it. In Table 9, we summarize several key contributions of the study and the opportunities for future research.

Table 9. Key Contributions

Main findings	Way forward
Authors and institutional networks: preferential attachment phenomenon exists in the ITM network: new incoming nodes (authors and institutions) attach preferentially to the nodes that are already well placed and are in a position of real importance in the network.	Future research should look into the effects of the preferential attachment phenomenon on the overall health of the ITM domain. Is it a good or bad condition for the ITM domain? And how should the domain effectively address it?
Authors and institutional networks: the ITM community is unique: it has several distinct schools of thought in which different hypotheses are pursued by those that often belong to the same institutions but whom do not collaborate.	Future studies should investigate why such a network configuration exists in the ITM domain and whether this network configuration also exist in other IS communities? Another area open for future research are the effects of the inter-departmental collaboration arrangements over the research agenda and directions. For example, how does this lack of inter-departmental collaboration affect the overall ITM research agenda and health?
Country-level network: lack of collaboration among developing and developed countries in the ITM domain. Most developing countries do not participate in the collaboration network.	The lack of collaboration among developing and developed countries is alarming and calls for investigations into its effects on ITM-related research and practice in developing countries. And how does this lack of collaborations relate to the overall diversity of the IS and ITM research?
The SNA technique: considering the potential of the SNA technique, our results call for a need to update our existing understanding of the literature review method (i.e., a structured way of dealing with analyzing and synthesizing either a mature or emerging topic while facilitating theory development and uncovering areas that needs more research).	We need future research to investigate the possibilities of qualifying the SNA technique as an “effective review” method capable of revealing certain hidden knowledge beyond the scope of systematic literature review methods.
IS/ITM Diversity: the IS/ITM research diversity questions should focus not only on the eminent genre but also the network arrangements of nations, institutions, journals, and authors in a knowledge network.	From a diversity perspective, we call for an investigation into the IS research diversity status from the viewpoint of network arrangements of nations, institutions, journals, and authors in the IS knowledge network and potential other research domains.

First, we found evidence among the knowledge and sematic networks to suggest that they exhibited a power law distribution in which the incoming nodes and links prefer to attach to the nodes that are already well connected. This finding is significant and opens up opportunities for new research questions. While the existence of preferential attachment phenomena is interesting, it is not clear how bad or good is it to the overall health of ITM research domain. For example, for ITM, it could mean that new follow-on studies frequently use a few popular keywords or themes (Choi et al., 2011). It could also mean new researchers tend to form collaboration links with well-established scholars to get published and recognized. As such, we might ask how this tendency affects the overall research agenda and performance of the ITM domain? The existence of preferential attachment phenomenon coupled with a higher number of structural holes in the ITM domain is problematic. The network structure can certainly affect a research domain’s overall health and performance (Vidgen et al., 2007). For example, researchers have linked a higher number of structural holes to a lack of performance and innovation capabilities in a network (Ahuja, 2000; Guan et al., 2015). To some extent, the ITM domain can strategically address these issues: 1) the ITM authors need to form collaboration ties through means other than previous co-authorships ties, such as through personal and professional social gatherings (e.g., academic conferences), 2) ITM authors should collaborate and network more with other departments in their universities, 3) the ITM authors and institutions should seek to collaborate with a diverse range of collaborators, and 4) new ITM authors, in addition to establishing links with well-established authors, should also forge ties with other emerging authors instead of only trying to publish with well-established authors who have a well-established agenda.

Second, by constructing the collaboration network from two different perspectives (i.e., author vs., institutional perspective), we also found evidence that the ITM collaborating network comprised several distinct schools of thought in which different hypotheses are pursued by those that often belong to the same institutions but whom do not collaborate. This finding is important in two ways. First, it sheds light on the previously unexplored network structure of the ITM knowledge infrastructure and its possible effects on the knowledge production in this domain. This finding is interesting and adds to our understanding, but, at the same, it opens up new areas for future research. For example, why does such a phenomenon exist? And how does this lack of inter-departmental collaboration affect the overall ITM research agenda? Second, this finding provides an interesting, yet simple way to detect such a phenomenon by examining the structures of the author- and institutional-level collaboration networks. If the author network is fragmented but the institutional level network is well formed, we might ask if the ITM domain is an emerging field that has yet to settle on a paradigm. Research scholars in other fields can use this method to look for such structural irregularities in their field, which they can easily do by collapsing the individual nodes (i.e., authors) that belong to the same institutions into a single node (i.e., institutions) and then comparing the two network structures. A fragmented author network but a well-formed institutional level network is the first sign of research collaboration irregularities.

Third, we compared the ITM network with other IS allied community networks reported in the literature, such as electronic government (e-government) (Khan & Park, 2013), IT outsourcing (Swar & Khan, 2013), the ICIS (Xu & Chau, 2006), ECIS (Vidgen, et al., 2007), and IRIS (Trier & Molka-Danielsen, 2013) (see Table 10). Table 10 shows that the network structure of the ITM network is structurally similar to the e-government, IT outsourcing, and ICIS networks, which are small world networks (Xu & Chau, 2006; Khan & Park, 2013; Swar & Khan, 2013) (a small network is one in which there is a low level of separation among the nodes). However, previous studies do not report on any structural irregularities between the authors and institutional network; thus, we cannot comment on its nature. Nevertheless, the findings point to critical areas that we still need to investigate. By comparing the structures of authors and institutional networks, future studies can look into the nature of the collaboration in these communities, which could help to answer several pressing questions, such as do several distinct schools of thought exist? Are they pursuing different hypotheses? Do they belong to the same department? And how such arrangements affect the overall nature of the research collaborations and outcomes?

Fourth, based on our results, we also call for updating the existing understanding of the literature review method (i.e., a structured way of dealing with analyzing and synthesizing either a mature or emerging topic while allowing one to develop theory and uncover areas that needs more research) (Webster & Watson, 2002). As we demonstrate here, when used to synthesize the existing literature from a network perspective, the SNA technique can reveal valuable invisible patterns that can certainly facilitate theory development and uncover areas for future research. Hence, SNA can qualify what Webster and Watson (2002) call as an "effective review" method capable of revealing certain hidden knowledge beyond the scope of systematic literature review methods.

Finally, the institution-level network showed that the Universities of Maryland and Georgia State and institutions such as the IBM Research Division and the IBM Global Technology Service have high levels of network interconnectivity and linkages with other universities, which demonstrates their ability to use their position at the center of the network to influence the spread of information that flows through it. Apart from having the ability to forge collaboration ties with multiple disconnected institutional clusters and using their existing network connections to obtain information advantages, the findings also imply that the research agendas that these central players pursue are more likely to set the current and future ITM research directions. We analyzed the key research themes by these central players and confirmed this argument and showed that the themes the central players pursue are, indeed, central to the overall ITM collaboration network. For example, key research themes that the IBM research division conducted focused of coordination, strategic partnerships, and business design in IT, while the University of Maryland provided a great deal of work on the effectiveness and role of CIO in IT organizational management. Another important player was Georgia State University. Its key research areas focused on strategic IT alignment, CIO and managerial performance, and IT architecture and governance. IBM's strong showing in this regard reflects the organization's long history in the IT domain and its strong commitment to helping build greater knowledge and understanding in it. For the ITM network to continue to grow, these IBM divisions need to continue to play center stage. However, as a result, the research themes that the central players pursue may make the ITM research domain less diverse. For example, researchers may overlook and not properly research important research themes (such as issued faced by developing countries in the ITM domain or the cross cultural issues). For instance, most of the institutions in the developing countries were poorly connected to the network, while, from a local Asian perspective, the HAC rankings of Yonsei University in particular showed that it was poorly connected and placed to exploit any network opportunities as a leading university in the region. It needs to reassess the ways in which it applies its resources so that it is better placed to connect with other leading institutions in the future.

Table 10. Comparison of Network Structure of Electronic Government, IT Outsourcing, ICIS, ECIS, IRIS, and the ITM

Community	E-gov[i]	IT outsourcing	ECIS	ICIS	IRIS	ITM
Reported in	Khan & Park (2013)	Swar & Khan (2013)	Vidgen et al (2007)	Xu & Chau (2006)	Trier and Danielsen (2013)	This paper
Main component size in %	3.02	4.46	30	65	60	2.25
Density of the network	<1%	<1%	<1%	<1%	<1%	<1%
Number of nodes	1,889	471	2,009	1,862	1,360	1,914
Diameter	10 steps	5 steps	31 steps	Not reported	17 steps	7 steps
Small world property	Small world	Small world	"Non-small world	Small word	Non-small world	Small world
Scale-free property	Scale free	Scale free	Scale free	Scale free	Scale free	Scale free
Highest degree (author)	20	12	59	36	41	29
Average degree	2.53	1.92	Not defined	3	4	3.13
Share of single authors	12.55%	11.46%	Not defined	8%	22%	9.61%

[i] We obtained these properties from the authors directly because the original paper does not report them.

5.5 Limitations

The study has several limitations. We studied only the sources indexed in the WOS database; thus, we excluded several other sources publishing ITM-related research not listed in the WOS from the analysis. Thus, one should exercise caution when generalizing the results. The size and structure of a co-authorship network depends on the total population and economic status of a country and/or instructions. For example, larger and/or richer countries will have more resources, researchers, and instructions to carry out research, which leads to a strong network position in the knowledge network infrastructure. However, in this research, we did not control for the size of the countries and institutions. Future research may investigate these types of interdependences. One of the potential disadvantages of using the SNA as a scientometric tool is that network statistics (such as degree distribution) may not (in some cases) reveal real author contribution. For example, during our analysis, we found that some authors who published one paper with eight co-authors had the same degree (number of collaboration ties) as the author who wrote four papers with one co-author. We also found that an author who had eight single-authored papers had no collaboration ties. Thus, one should interpret network statistics as a proxy for measuring collaborations ties and not publication performance.

6 Conclusion

By employing the social network analysis technique, we investigated and decomposed the semantic and knowledge networks of the information technology management (ITM) domain. By incorporating the network- and ego-level properties of degree centralities, density, components, structural holes, and degree distribution, our results suggest that the ITM is a community of a unique character where several distinct schools of thought in which different hypotheses are pursued by those that often belong to the same institutions, but do not collaborate. The results also showed that the knowledge and semantic networks included in our study exhibited the power law distribution in which incoming nodes and links prefer to attach to the nodes that are already well connected. Future research should address how such network configurations affect the overall research agenda and performance of the ITM domain.

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